Production Potential and Evaluation of Establishment Methods to Over-sow Kikuyu with Grass and Legume Species

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Introduction

Kikuyu is a pasture species that is well adapted to the main milk producing areas in the Western Cape Province of South Africa (Botha 2003). The strategic incorporation of various temperate grasses and legume species, over-sown during autumn, has been found to be an economical forage-based way to improve the seasonal dry matter (DM) production, forage quality and milk production potential of kikuyu based pasture systems (Botha 2003, Fulkerson et al. 1993a, Van der Colf 2011). The species that have thus far been evaluated by over-sowing them into kikuyu include westerwolds ryegrass, Italian ryegrass, perennial ryegrass, red- and white clover mixtures, perennial ryegrass-clover mixtures, rescue grass (*Bromus catharticus*) and tall fescue (Betteridge 1985, Hill 1985a, Betteridge and Haynes 1986, Harris and Bartholomew 1991, Davison et al. 1997a, Botha et al. 2008a, Botha et al. 2008b, Van der Colf et al. 2011). The preferred species to include in a kikuyu based system will be based on factors such as fertiliser costs, milk price, ease of management and the availability of natural resources, especially water (Botha et al. 2008a).

To date, kikuyu-ryegrass pastures have been favoured over kikuyu-clover pastures in the main milk producing areas of the Western Cape due to the fact that these systems are easy to manage, requires fewer field operations to establish and has a high seasonal DM production potential (Davison et al. 1997a, Botha et al. 2008a). Such kikuyu-ryegrass systems can maintain pasture production rates of between 15 and 18 t DM ha^{-1} $annum^{-1}$ (DM intake basis) and achieve milk production rates of approximately 30 000 kg FCM ha^{-1} (Van der Colf 2011). However, due to the high fertilisation rate (500 kg N ha^{-1} $annum^{-1}$) and irrigation requirements of kikuyu-ryegrass pastures, the sustainability of such systems in the future is questionable. The inclusion of legumes and perennial grasses is the most likely way to streamline pasture systems so as to increase long-term survival and sustainability (Cransberg and McFarlane 1994). Perennial legumes such as white clover hold the potential to fix atmospheric nitrogen, provide high quality feed for livestock (Brock and Hay 2001) and decrease the reliance on expensive nitrogen fertilisation (Graham and Vance 2003, Neal et al. 2009).

The direct challenge in the development of systems based on over-sowing kikuyu with adapted perennial grasses in mixtures with perennial clovers is the successful establishment and long-term persistence of these species in order to improve the production potential of the system as a whole. The objective in the establishment of such pastures will be to maintain perennial pasture with optimum seasonal production, and to maintain the clover content above 30% of the botanical composition during winter and up to 50% during spring (Botha et al. 2008a) (Kemp et al. 2000). The aim of this study was to evaluate various methods to establish tall fescue and cocksfoot in mixtures with white and red clover into existing kikuyu-based pastures.

Materials and methods

The study was carried out on existing kikuyu pasture under permanent irrigation on the Outeniqua Research Farm (altitude 210 m, 33°58'38" S and 22°25'16"E) in the Western Cape Province of South Africa. The area is characterised by an Estcourt soil type (Soil Classification Work group 1991). The study consisted of a randomized block design with three blocks that acted as replicates and to which treatments were randomly allocated. The pasture treatments are described in terms of abbreviation, common name, scientific name and seeding rate in Table1

Table 1: Treatment abbreviation, common name, scientific name and seeding rate of pasture treatments.

Abbreviation	Common name	Scientific name	Seeding rate (kg ha^{-1})
Cocksfoot mixture	Kikuyu	*Pennisetum clandestinum*	Existing pasture
	Cocksfoot	*Dactylis glomerata*	10
	White clover	*Trifolium repens*	4
	Red clover	*Trifolium pratense*	4
Tall fescue mixture	Kikuyu	*Pennisetum clandestinum*	Existing pasture
	Tall fescue	*Festuca arundinacea*	10
	White clover	*Trifolium repens*	4
	Red clover	*Trifolium pratense*	4

Table 2: Treatment abbreviation, herbicide treatment, cultivation and description of establishment method to be used during the trial

Treatment	Treatment abbreviation	Herbicide treatment	Cultivation	Establishment method
1	Mulch	Nil herbicide	Mulcher	Graze to 50 mm Broadcast seed Mulch to ground level Roll with teff roller
2	Planter		Planter	Graze to 50 mm Mulch to ground level Plant with Aitchison seeder Roll with teff roller
3	Rotavate		Rotavate	Graze to 50 mm Mulch to ground level Rotavate to 120 mm Roll with teff roller Broadcast seed Roll with teff roller
4	Gly+Mulch	Glyphosate	Mulcher	Graze to 50 mm Spray with glyphosate (5 L ha^{-1}) Broadcast seed Mulch to ground level Roll with teff roller
5	Gly+Plant		Planter	Graze to 50 mm Spray with glyphosate (5 L ha^{-1}) Mulch to ground level Plant with Aitchison seeder Roll with teff roller
6	Gly+Rot		Rotavate	Graze to 50 mm Mulch to ground level Spray with glyphosate (5 L ha^{-1}) Rotavate to 120 mm Roll with teff roller Broadcast seed Roll with teff roller
7	Par+Mulch	Paraquat	Mulcher	Graze to 50 mm Spray with paraquat (5 L ha^{-1}) Broadcast seed Mulch to ground level Roll with teff roller
8	Par+Planter		Planter	Graze to 50 mm Spray with paraquat (5 L ha^{-1}) Mulch to ground level Plant with Aitchison seeder Roll with teff roller
9	Par+Rotavate		Rotavate	Graze to 50 mm Mulch to ground level Spray with paraquat (5 L ha^{-1}) Rotavate to 120 mm Roll with teff roller Broadcast seed Roll with teff roller

Table 3: The total annual dry matter production of different components and whole sward for cocksfoot-perennial legume mixtures over-sown using different methods during year 1.

Method	Clover	Sown grass	Kikuyu	Other	Whole sward
Mulch	3.11^{b}	0.84^{c}	1.45^{a}	6.46^{ab}	11.9^{a}
Planter	3.91^{ab}	1.31^{bc}	1.34^{ab}	8.45^{a}	15.0^{a}
Rotavate	4.28^{ab}	2.27^{ab}	0.27^{c}	4.85^{bc}	11.7^{a}
Par + Mulch	4.71^{ab}	1.53^{abc}	0.56^{bc}	5.06^{bc}	11.9^{a}
Par + Plant	4.80^{ab}	2.02^{ab}	1.63^{a}	5.27^{abc}	13.7^{a}
Par + Rot	5.41^{a}	2.63^{a}	0.05^{c}	2.95^{c}	11.0^{a}
Gly + Mulch	5.89^{a}	1.86^{abc}	0.01^{c}	3.66^{bc}	11.4^{a}
Gly + Plant	4.29^{ab}	1.94^{abc}	0.01^{c}	5.83^{abc}	12.1^{a}
Gly + Rot	4.18^{ab}	2.61^{a}	0.01^{c}	3.37^{bc}	11.4^{a}
LSD (0.05)	2.068	1.112	0.778	3.373	4.259

LSD (0.05) compares within component

^{abc}Means with no common super script differed significantly

Table 4: The total annual dry matter production of different components and whole sward for cocksfoot-perennial legume mixtures over-sown using different methods during year 2.

Method	Clover		Sown grass		Kikuyu		Other		Whole Sward	
	Perennial	Over-sow	Perennial	Over-sow	Perennial	Over-sow	Perennial	Over-sow	Perennial	Over-sow
Mulch	1.55^{abcde}	1.37^{abcde}	3.32^{abc}	3.06^{bc}	2.33^{b}	2.07^{bc}	3.48^{abcd}	2.32^{abcde}	11.4^{ab}	9.62^{b}
Planter	2.25^{a}	1.35^{abcde}	2.11^{c}	3.14^{bc}	4.50^{a}	1.72^{bcde}	3.78^{ab}	4.10^{a}	14.7^{a}	12.0^{ab}
Rotavate	2.08^{ab}	1.16^{bcde}	4.84^{ab}	4.38^{abc}	0.96^{bcdef}	0.51^{cdef}	1.56^{cde}	2.10^{abcde}	10.4^{ab}	8.62^{b}
Par + Mulch	1.71^{abcde}	0.83^{de}	4.10^{abc}	3.96^{abc}	2.21^{b}	0.42^{def}	1.85^{bcde}	1.85^{bcde}	11.0^{ab}	8.05^{b}
Par + Plant	1.91^{abcd}	1.63^{abcde}	4.19^{abc}	4.45^{abc}	1.97^{bcd}	1.93^{bcd}	2.90^{abcde}	2.18^{abcde}	11.0^{ab}	10.2^{ab}
Par + Rot	2.03^{abc}	1.05^{bcde}	5.40^{ab}	4.33^{abc}	0.50^{cdef}	0.15^{ef}	2.68^{abcde}	1.36^{de}	11.4^{ab}	7.90^{b}
Gly + Mulch	1.73^{abcde}	0.70^{e}	5.60^{a}	4.33^{abc}	0.02^{f}	0.04^{f}	1.29^{e}	1.28^{e}	9.50^{b}	7.25^{b}
Gly + Plant	2.26^{a}	1.25^{abcde}	4.35^{abc}	3.81^{abc}	0.02^{f}	0.03^{f}	3.54^{abc}	1.73^{bcde}	10.8^{ab}	7.73^{b}
Gly + Rot	2.30^{a}	0.99^{cde}	5.05^{ab}	5.33^{ab}	0.13^{ef}	0.03^{f}	3.45^{abcd}	2.13^{abcde}	11.7^{ab}	9.32^{b}
LSD (0.05)	1.084		2.381		1.630		2.138		4.771	

LSD (0.05) compares within component

^{abc}Means with no common superscript differed significantly

The establishment methods used during the study were aimed at including techniques based on herbicidal and mechanical control of kikuyu. A detailed description of the nine establishment methods is given in Table 2. When herbicides formed part of the treatment, it was applied to the specific plots 14 days prior to the any tillage/mechanical actions at a rate of 5 L ha^{-1} for both paraquat (contact) and glyphosate (systemic). The remaining material on herbicide plots was removed by grazing prior to establishment as recommended by Fulkerson and Slack (1996) and Fulkerson and Reeves (1996).

It has been recommended that temperate species be over-sown into kikuyu on an annual basis in order to maintain maximum returns from fertilizer and irrigation inputs on such pastures (Goodchild et al. 1982). In current kikuyu systems, perennial ryegrass is over-sown on an annual basis due to poor persistence (Botha et al. 2008, Van der Colf 2011), but the persistence of other temperate perennial species over years and the effect of annual over-sowing on botanical composition is not fully understood. In order to evaluate the changes that occur in un-renovated pastures over years and to determine whether annual over-sowing is the most economical means whereby production of these systems will be maintained, plots were divided into subplots that either remained un-renovated or were annually over-sown during the trial period. Annually over-sown plots were grazed to 50 mm during April, mulched to ground level and legumes and grasses were planted with a no-till Irrigation was scheduled using tensiometer readings placed at a depth of 150 mm. Irrigation commenced at a tensiometer reading of –25 kPa (Botha 2002). Soil samples were taken before the commencement of pasture establishment to a depth of 100 mm. Fertiliser was applied according to soil analysis results to raise soil P level (citric acid method) to 35 mg kg^{-1}, K level to 80 mg kg^{-1} and the pH (KCl) to 5.5 (Beyers 1973). Pastures received a once-off nitrogen dressing of 50 kg N ha^{-1} during winter in year 2.

Dry matter yield (kg DM ha^{-1}) was determined every 28 days by cutting four 0.25 m^2 quadrats to a height of 50 mm per plot before and after grazing. Samples were dried at 60ºC for 72 hours, DM content was determined and the yield estimated as kg DM ha^{-1}. Botanical composition was determined on a seasonal basis from grab samples. Pastures were grazed by lactating Jersey cows when pasture where deemed ready for grazing (between 28 and 35 days), with grazing management aimed maintaining a post grazing height of approximately 50 mm above ground level.

An appropriate analysis of variance (ANOVA) was performed, normality of residuals was tested (Shapiro and Wilk 1965) and Student's t-LSD (Ott 1993) calculated at a 5% significance level to compare treatment means. The STATS module of SAS version 9.2 was used to analyse data (SAS 2008).

Table 5: The total annual dry matter production of different components and whole sward for fescue-perennial legume mixtures over-sown using different methods during year 1.

Method	Clover	Sown grass	Kikuyu	Other	Whole sward
Mulch	3.43^{ab}	1.41^{ab}	0.93^{a}	4.71^{ab}	10.5^{a}
Planter	3.17^{b}	1.05^{abc}	1.07^{a}	4.83^{ab}	10.1^{a}
Rotavate	4.87^{ab}	1.27^{abc}	0.36^{a}	2.93^{b}	10.2^{a}
Par + Mulch	5.02^{ab}	0.26^{c}	1.01^{a}	3.49^{ab}	11.2^{a}
Par + Plant	4.99^{ab}	0.92^{abc}	0.85^{a}	5.55^{a}	12.3^{a}
Par + Rot	6.14^{ab}	1.92^{a}	0.17^{a}	2.88^{b}	11.1^{a}
Gly + Mulch	6.08^{ab}	0.61^{bc}	0.06^{a}	5.22^{ab}	12.9^{a}
Gly + Plant	5.02^{ab}	0.64^{bc}	0.06^{a}	5.77^{a}	11.5^{a}
Gly + Rot	6.46^{a}	0.59^{bc}	0^{a}	3.50^{ab}	11.8^{a}
LSD (0.05)	3.070	1.075	1.146	2.378	3.459

Results and discussion

Cocksfoot-perennial legume mixture

The total annual DM production of different components and the whole sward for a cocksfoot-perennial legume mixture over-sown into kikuyu using different establishment methods during year 1 is shown in Table 3. The total annual DM yield of the whole sward of the cocksfoot-perennial legume mixture was not affected by establishment method in year 1. All methods, except the mulcher method had both a clover and sown grass yield that was the highest or similar to the highest during year 1. When sown grass yield is considered alone, all methods except the mulcher and planter methods had a higher DM production. The mulcher, planter and par+planter methods had both kikuyu and other yields that were the highest or similar to the highest yield in year 1. The total annual DM production of different components and the whole sward for a cocksfoot-perennial legume mixture over-sown into kikuyu using different establishment methods during year 2 is shown in Table 4. During year 2 there were no differences in the sward, clover or sown grass production between pastures that were un-renovated or over-sown annually in year 2. This may be attributable to the production that is 'sacrificed' when annually over-sown pastures are establishing. Results indicate that if a high sown grass and clover component is desired for a cocksfoot-perennial legume mixture, shallow cultivation or herbicidal control is recommended. The most suitable method of these methods employed will likely be determined by establishment costs, rather than yield alone

Fescue-perennial legume mixture

The total annual DM production of different components and the whole sward for a fescue-perennial legume mixture over-sown into kikuyu using different establishment methods during year 1 is shown in Table 5. The whole sward yield and kikuyu yield was not affected by establishment method for the fescue-perennial legume mixture during year 1. The mulcher, rotavate, par+plant and par-rot were the only methods where both the clover yield and sown grass yield was highest or similar to the highest during year 1. The total annual DM production of different components and the whole sward for a fescue-perennial legume mixture over-sown into kikuyu using different establishment methods during year 2 is shown in Table 6. During year 2 the total sward yield was lower in annually over-sown than un-renovated fescue-perennial legume mixtures for the mulcher, Par+planter, Par+rot and Gly+plant methods. Once again, this was likely due to production 'sacrificed' during the establishment phase after annually over-sowing. The un-renovated Par + Rot, Gly+Mulch, Gly+Plant and Gly+Rot were the only treatments that had both a clover and sown grass yield that was highest or similar to the highest in year 2.

The preferable methods to manage a fescue-perennial legume mixture over-sown into kikuyu was thus to use herbicide in the initial establishment, and managed as a perennial pasture that is not over-sown on an annual basis.

Table 6: The total annual dry matter production of different components and whole sward for fescue-perennial legume mixtures over-sown using different methods during year 2.

Method	Clover		Sown grass		Kikuyu		Other		Whole Sward	
	Perennial	Over-sow	Perennial	Over-sow	Perennial	Over-sow	Perennial	Over-sow	Perennial	Over-sow
Mulch	1.30^{de}	1.19^{e}	2.64^{a}	1.57^{abc}	2.51^{ab}	0.77^{cdef}	3.25^{ab}	3.36^{ab}	10.6^{a}	7.95^{c}
Planter	1.70^{cde}	1.22^{e}	1.46^{bc}	1.67^{abc}	3.13^{a}	0.93^{bcdef}	3.07^{b}	3.64^{ab}	10.2^{ab}	8.50^{bc}
Rotavate	1.64^{cde}	2.86^{abcd}	2.25^{ab}	1.33^{bc}	1.72^{abcde}	0.98^{bcdef}	3.57^{ab}	2.90^{b}	9.67^{abc}	8.76^{abc}
Par + Mulch	2.21^{bcde}	1.62^{cde}	1.40^{bc}	1.16^{bc}	2.20^{abc}	2.00^{abcd}	3.55^{ab}	3.28^{ab}	10.3^{ab}	8.84^{abc}
Par + Plant	2.16^{bcde}	1.52^{cde}	1.09^{c}	1.14^{bc}	1.81^{abcde}	1.07^{bcdef}	4.63^{ab}	3.48^{ab}	10.2^{ab}	8.02^{c}
Par + Rot	3.08^{abc}	1.40^{de}	2.08^{abc}	1.91^{abc}	0.60^{def}	0.67^{cdef}	3.78^{ab}	3.53^{ab}	10.6^{a}	8.38^{bc}
Gly + Mulch	3.46^{ab}	1.88^{bcde}	1.95^{abc}	1.20^{bc}	0.24^{ef}	0.11^{f}	4.33^{ab}	4.90^{ab}	10.3^{ab}	9.05^{abc}
Gly + Plant	2.88^{abcd}	1.98^{bcde}	1.61^{abc}	1.58^{abc}	0.39^{ef}	0.01^{f}	5.11^{a}	3.89^{ab}	10.6^{a}	8.39^{bc}
Gly + Rot	4.03^{a}	2.84^{abcd}	1.54^{abc}	1.42^{bc}	0.01^{f}	0.0^{6}	4.00^{ab}	3.38^{ab}	10.4^{ab}	8.72^{abc}
LSD (0.05)	1.609		1.117		1.601		2.032		2.014	

LSD (0.05) compares within component

^{abc}Means with no common superscript differed significantly

Conclusions

The establishment method to over-sow cocksfoot- and fescue-perennial legume mixtures into kikuyu did not affect total DM production of the sward. For both mixtures and methods where some degree of cultivation occurred or herbicide was sprayed resulted in a higher sown grass and clover yield. For cocksfoot-perennial legume mixtures the annual over-sowing did not affect total, clover or sown grass production. Fescue-perennial mixtures had higher clover, sown grass and sward yields for un-renovated treatments. When over-sowing temperate grass-legume mixtures into kikuyu the component yields (sown grass and clover) and costs related to different methods should be considered when selecting an over-sowing method.

Message to the farmer

Grass-legume mixtures can be over-sown into kikuyu using various mechanical and herbicidal methods. The decision on which method to use should be based on the species being sown and costs related to establishment.

References

Betteridge K. 1985. Introducing temperate grasses into Kikuyu. In "Kikuyu grass farming for high production". Edited by G. Piggot. Published by Gallagher electronics, Hamilton. Pp. 36-39.

Betteridge K, Haynes DA. 1986. Altering the growth pattern of kikuyu pastures with temperate grasses. *Proceedings of the New Zealand Grassland Association* 47:149-156.

Beyers C. 1973. Bemesting van aangeplante weidings. *Winterreen spesiale uitgawe*, 5:64-59.

Botha P. 2002. Die gebruik van vogspanning-meters vir besproeiing-skeduleering by weidings. *Weidingskursusbundel Inligtingsbundel 2002* (pp. 141-149). George, Western Cape: Department of Agriculture: Western Cape.

Botha PR. 2003. Die produksie potensiaal van oorgesaaide kikuyu weiding in die gematigde kusgebied van die Suid-Kaap. PhD Thesis, University of the Free State, South Africa.

Botha PR, Meeske R, Snyman HA. 2008a. Kikuyu over-sown with ryegrass and clover: dry matter production, botanical composition and nutritional value. *African Journal of Range and Forage Science* 25: 93-101.

Botha PR, Meeske R, Snyman HA. 2008b. Kikuyu over-sown with ryegrass and clover: grazing capacity, milk production and milk composition. *African Journal of Range and Forage Science* 25: 103-110.

Brock J, Hay M. 2001. White clover performance in sown pastures: A biological/ ecological perspective. *Proceedings of the New Zealand Grassland Association 63* (pp. 73-83). New Zealand Grassland Association.

Cransberg L, & McFarlane D. (1994). Can perennial pastures provide the basis for sustainable farming system in southern Australia. *New Zealand Journal of Agricultural Research* 37: 287-294.

Davison TM, Frampton PJ, Orr WN, Silver BA, Martin P, McLachlan B. 1997a. An evaluation of kikuyu-clover pastures as a dairy production system 1. Pasture and diet. *Tropical Grasslands* 31: 1-14

Fulkerson WJ, Slack K. 1996. Maintaining white clover (*Trifolium repens*) in a kikuyu (*Pennisetum clandestinum*) pasture in the sub-tropics. Proceedings of the 8th Australian Agronomy Conference.

Fulkerson WJ, Reeves M. 1996. Management and productivity of white clover in a kikuyu grass sward in subtropical Australia. *Proceedings of the New Zealand Grassland Association* (pp. 199-201). New Zealand Grassland Association.

Fulkerson WJ, Lowe KJ, Ayres JF, Launders TT. 1993a. Northern dairy feedbase 2001 3. Winter pastures and crops. *Tropical Grasslands* 27: 162-179.

Goodchild IK, Thurbon PN, Sinnick R, Shepherd R. 1982. Effect of land preparation and nitrogen fertilizer on the yield and quality of temperate species introduced into tropical grass sward during autumn. *Australian Journal of Experimental Agriculture and Animal Husbandry* 22: 88-94.

Graham P, Vance C. 2003. Legumes: Importance and constraints to greater use. *Plant Physiology* 131: 972-877.

Harris DI, Bartholomew PE. 1991. The production of four ryegrass cultivars over -sown at various seeding rates into irrigated kikuyu. *Journal of the Grassland Society of South Africa* 8: 82-85.

Kemp D, Michalk D, Virgona J. 2000. Towards more sustainable pastures: Lessons learnt. *Australian Journal of Experimental Agriculture* 40:343-356.

Neal J, Fulkerson W, Lawrie R, Barchia M. 2009. Difference in yield and persistence among perennial forages used by the dairy industry under optimum and deficit irrigation. *Crop and Pasture Science*, 60:1071-1087.

Ott RL. 1993 An Introduction to Statistical methods and data analysis. Belmont, California:Duxbury Press: pp 807-837, pp 1-1051.

SAS Institute, Inc. 2008, SAS Version 9.2. SAS Institute Inc, SAS Campus Drive, Cary, North Carolina 27513.

Soil Classification Workgroup. 1991. *Soil Classification, A Taxonomic System for South Africa,. Memoirs on the Natural Agricultural Resources of South Africa.* Pretoria: Department of Agricultural Development.

Van der Colf 2011. The production potential of Kikuyu (*Pennisetum clandestinum*) pastures over-sown with ryegrass (*Lolium* spp.). MSc Dissertation: University of Pretoria, South Africa.